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**B8G** 1B 1D 4
**E1D** 1071 2071 401 405 413 427 CA
**E1S** LS7
**U1S** 1586 1596 B5A B8G E1D E1S

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**GB A 2041858** **GB 1305198**

(58) Field of search
**B5A**
**Selected US specifications from IPC sub-classes B29C B29D**

# (54) Improvements relating to fibre reinforced resin, lattice-type structures

(57) A rigid former (1) defines a number of interconnected channels (2) in a desired lattice array, along which reinforcing fibres e.g. of glass, are wound or laid under tension, the fibres either being pre-impregnated with resin, or alternatively the resin being injected after emplacement of the fibres in the channels. After resin curing, the former (1) may be removed, or alternatively the former may remain as part of the article.

The mesh strands may be overlaid with further fibres and resin, to effectively form the mesh structure into a network of interconnected ribs.

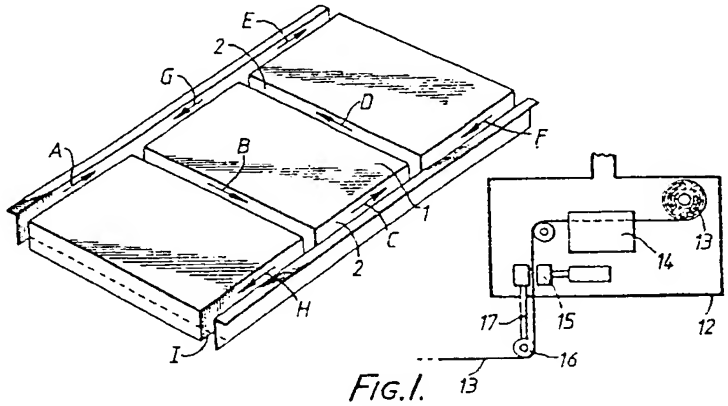


FIG. 1.

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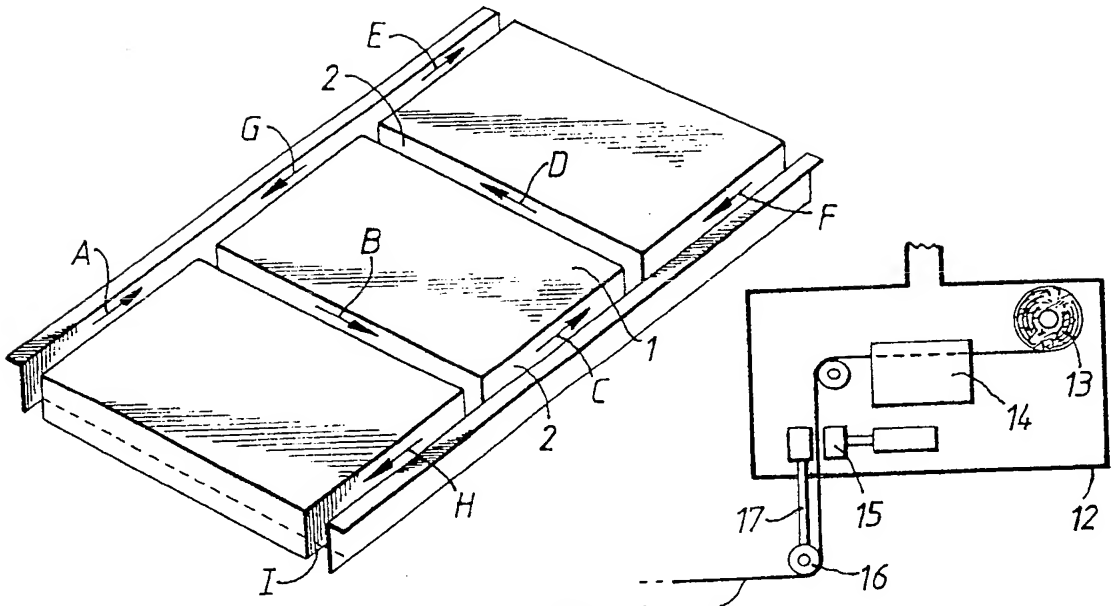


FIG. 1.

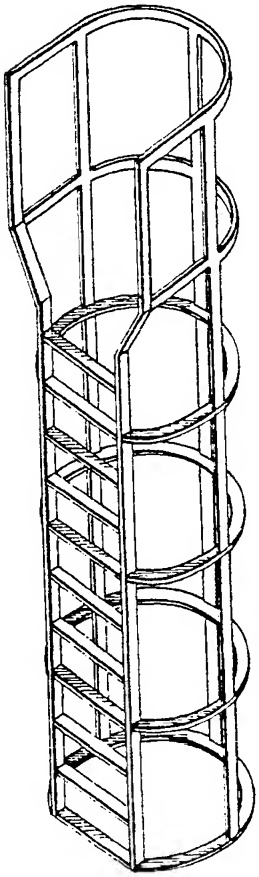

FIG. 2.

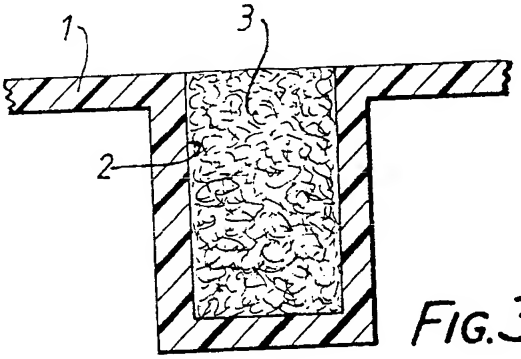


FIG. 3.

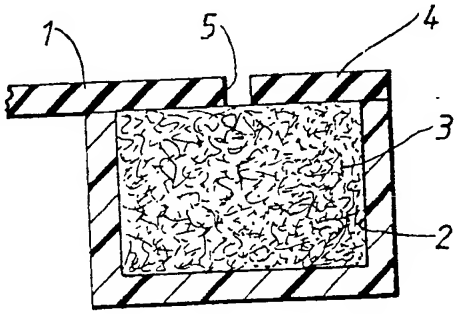


FIG. 4.

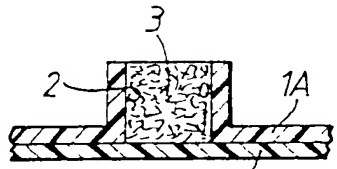


FIG.5.

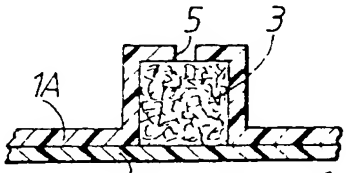


FIG.6.

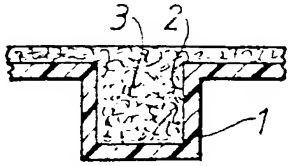


FIG.7.

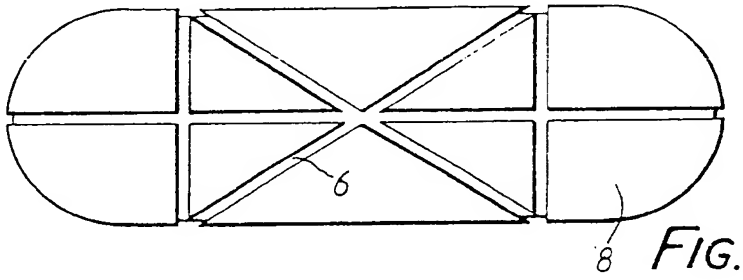


FIG.8.

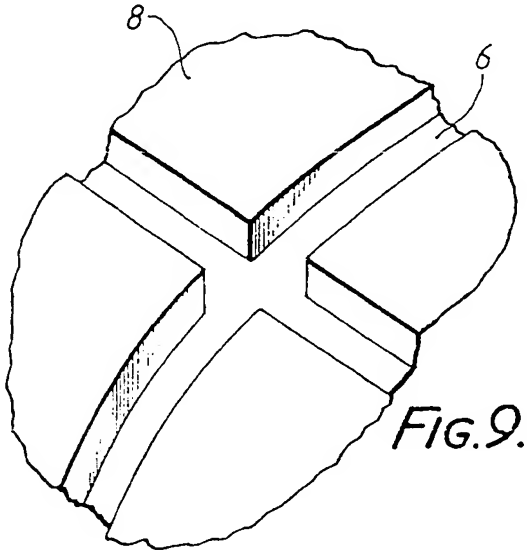


FIG.9.

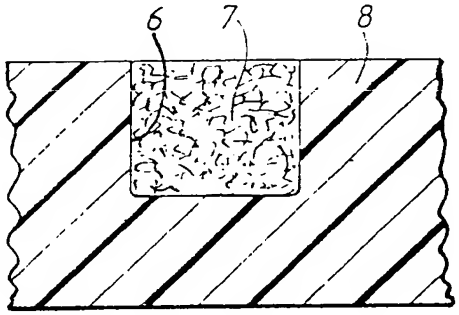


FIG.10.

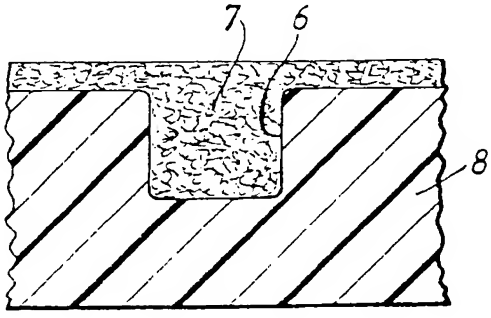


FIG.11.

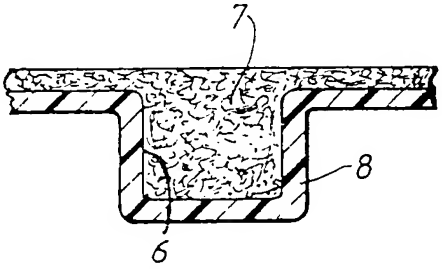


FIG.12.

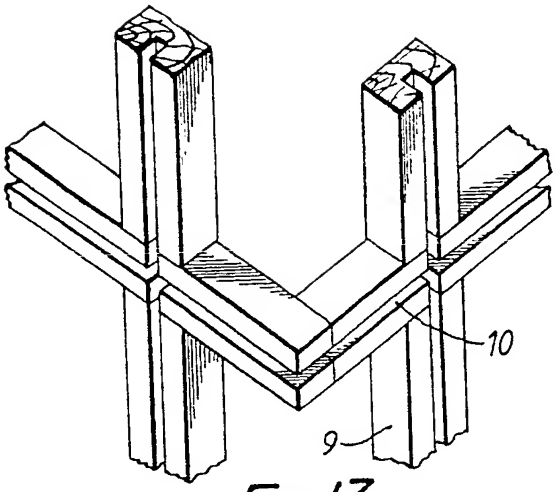


FIG.13.

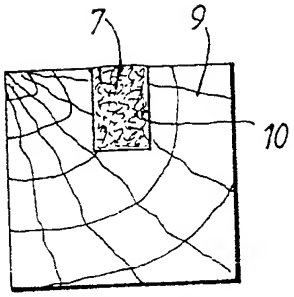


FIG.14

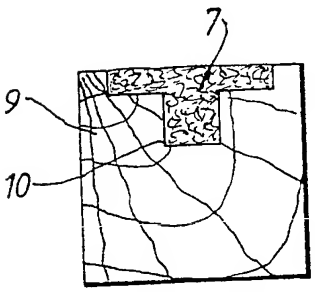


FIG.15.

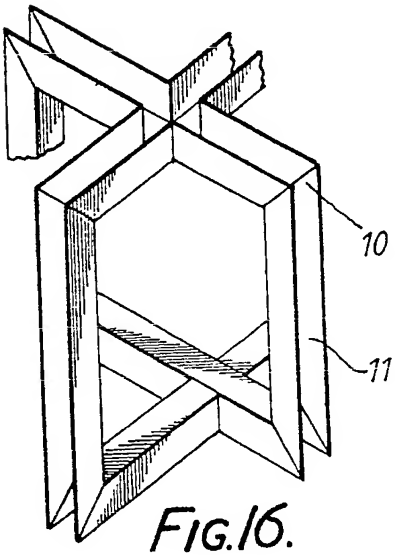


FIG.16.

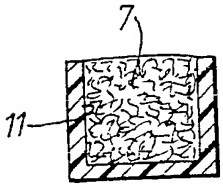


FIG.17.

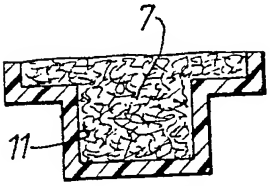


FIG.18.

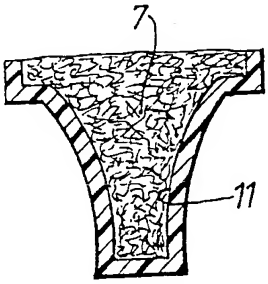


FIG.19.

SPECIFICATION

**Improvements relating to lattice-type structures**

This invention is concerned with the production of lattice-type structures. Currently such structures are made from rolled steel sections welded or bolted together or perhaps from reinforced concrete. It would be advantageous to fabricate such structures from glass fibre or other fibre reinforced plastics as they have inherent advantages over the existing materials used. However there has been no process available up to now which could create usable lattice-type structures economically.

According to the present invention there is provided a method of producing a lattice-type structure which comprises providing a former defining profiled channels in an array of the desired lattice shape, laying down fibres under tension by winding them throughout the array of channels, embedding the fibres in a resin, and allowing the resin to cure.

By drawing or laying the fibres under tension into the contours of the mould or former, the fibres are locked in by the shape and design of the former and are maintained in that shape by the cured resin. Hence a very strong lattice-type structure can be created in a relatively straightforward manner.

The former may be retained within the lattice-type structure as part of the support therefor. In many instances, however, it is envisaged that the former will serve the purpose of defining the shape of the final article so that the structure will be removed from the former after curing is complete.

The profiled channels may be open-topped but as a possible alternative the profiled channels can have a top wall defining a slot through which the fibres may be inserted into the channels. The portions of the top wall at least may be resiliently deformable to allow the cured structure to be released. The relevant parts of the former which need to be resiliently deformable could be made from a silicone rubber material which would be laid within the rigid parts of the former. As an alternative the former could be in two parts which are releasably attached to one another to enable the structure to be removed after curing by releasing the two parts.

The fibres can comprise wires formed from steel, aluminium, copper or other high modulus metal. In the preferred embodiment the fibres are formed from carbon-fibre glass fibre, Kevlar (Trade Mark) or other reinforced plastics. In this latter case the fibres could be impregnated or coated with resin before the placement operation. Generally resin may be injected into the channels of the former after emplacement of the fibres.

The fibres may be laid under the control of a winding machine so that the process could be entirely automatic. Lattice-type structures which may be created include ladders, safety cages, grids, beams and pylons, or such items as bridge beams and roof support members. The former can additionally be over-wound, partially or wholly, to provide a complete shell with an integral structural frame for such items as car body frames, submarine shells and aircraft fuselages.

The invention extends also to a lattice-type structure formed by the method of this invention as hereinbefore defined.

The invention may be performed in various ways and preferred embodiments thereof will now be described with reference to the accompaying drawings, in which:-

*Figure 1* is a perspective view of a former to be used in constructing a lattice-type structure of this invention;

*Figure 2* illustrates a type of structure which might be produced using a former of the type shown in Figure 1;

*Figure 3* is a cross section through a channel created in the former;

*Figures 4* to *7* illustrate modified forms of channel construction to be incorporated in the former of Figure 1; and

*Figures 8* to *19* illustrate a number of alternative structural designs of lattice-type structures of this invention.

A rigid former 1 shown in Figure 1 defines a number of interconnected channels 2 creating an array of channels in a desired lattice shape. Glass fibres are wound throughout the channels 2 by being drawn or laid under tension. The path taken by the fibres follows the arrows A, B, C, D and E, across the end of the former 1 and then back through the channels defined by the arrows F, D, G, B and H and back again to the starting point via an undercut channel I. The fibres are impregnated with resin before the placement operation or alternatively the resin is injected after emplacement of the fibres. After curing of the resin the item is removed from the former 1.

The former shown in Figure 1 would be used, for example, to form a ladder structure and could of course be extended in length or width as required and to produce ladders having any desired number of rungs, and possibly an integral safety cage, such as is illustrated in Figure 2. The former could be of a shape for constructing such items as grids, beams or pylons.

Figure 3 illustrates the shape of the channels 2 and shows a channel filled with fibres 3 in a resin matrix. The cured item can be lifted out of these channels 2.

In an alternative arrangement, as illustrated in Figure 4, the channel 2 is formed with a top wall 4 incorporating a slot 5 through which the fibres may be inserted for incorporation in the required manner in the channel 2. The top wall 4 at least will be formed from a resilient material (for example, silicone rubber) so that the cured structure can be removed from the former by forcing aside the parts of the top wall 4. A channel insert formed from a resilient material and having a shape as shown in Figure 4 could be employed for incorporation in a rigid channel 2 of the former 1.

Figures 5 and 6 illustrate modifications of the formers of Figures 3 and 4 fabricated in two parts 1A and 1B which can be detached from one another, to enable the cured structure to be released with ease. Figure 7 shows how the fibres 3 and curing resin may also be overlaid onto an external face of the former 1

prior to subsequent removal after curing of the structure.

The construction illustrated in Figure 8 and in the enlarged detail shown in Figure 9 comprises a former made from a pre-moulded rigid foam or a rigid plastics or reinforced plastics material, through which channels 6 have been formed during the moulding process. The channels can be of any configuration such as hoops, longitudinal, horizontal or random, as determined by the design of the structure.

As shown in Figure 10 the fibres 7 are laid down in the channels 6 and resin is cured about the fibres. After curing, the former 8 becomes an integral part of the finished structure. Additionally, the whole former could be over-wound or over-laid (as illustrated in Figures 11 and 12) to encase the former either partially or completely.

In the alternative constructions shown in Figures 13 to 15 the former is constructed from timber beams 9 with channels 10 machined in the outer faces. Again the fibres are wound, laid or placed in these channels and the resin is allowed to cure as before. The timber beams remain as part of the structure.

In the arrangements shown in Figures 16 to 19 the former is constructed from pre-formed sections of plastics steel, aluminium or other convenient material. Joints 10 between the sections can be made by bolting, welding or glueing so that the construction defines a number of channels 11 into which resin-impregnated fibres are wound, laid or placed. After curing the former 1 is left in place so that the pre-formed channels become an integral part of the finished item. Various channel shapes may be employed as illustrated in Figures 17 to 19.

Figure 1 additionally shows a unit for winding the fibres under tension throughout the array of channels 2 in the former 1. A container 12 which is movable on a gantry incorporates a reel of fibre 13. The fibre is passed through a resin tank 14 and then through a gripping device 15 which enables the required tension to be applied. The fibre 13 then passes round a guide wheel 16 carried on an arm 17 which will be moved through the channels 2 in the desired sequence.

CLAIMS

1. A method of producing a lattice-type structure which comprises providing a former defining profiled channels in an array of the desired lattice shape, laying down fibres under tension by winding them throughout the array of channels, embedding the fibres in a resin, and allowing the resin to cure.

2. A method according to claim 1, wherein the profiled channels are open-topped.

3. A method according to claim 1, wherein the profiled channels have a top wall defining a slot through which the fibres may be inserted into the channels.

4. A method according to claim 1, wherein the cured structure is subsequently removed from the former.

5. A method according to claim 3, wherein the portions of the top wall at least are resiliently deformable to allow the cured structure to be released.

6. A method according to claim 3, wherein the former is in two parts which are releasably attached to one another to allow the cured structure to be released.

7. A method according to claim 1, wherein the former forms an integral part of the final structure.

8. A method according to claim 1, wherein the former and the lattice-type structure are fully or partially overwound with fibres in a resin matrix or overlaid with a coating material.

9. A method according to claim 1, wherein the fibres are impregnated or coated with resin before the placement operation.

10. A method according to claim 1, wherein the resin is injected into the channels of the former after emplacement of the fibres.

11. A method according to claim 1, wherein the fibres are laid under control of a winding machine.

12. A lattice-type structure formed by a method as defined in claim 1.

Amendments to the claims have been filed, and have the following effect:-

*(a) Claims 4 to 12 above have been deleted or textually amended.

*(b) New or textually amended claims have been filed as follows:-

4. A method according to any one of claims 1 to 3, wherein the cured structure is subsequently removed from the former.

5. A method according to claim 3 in combination with claim 4, wherein the portions of the top wall at least are resiliently deformable to allow the cured structure to be released.

6. A method according to claim 3 in combination with claim 4, wherein the former is in two parts which are releasably attached to one another.

7. A method according to any one of claims 1 to 3, wherein the former forms an integral part of the final structure.

8. A method according to any one of claims 1 to 7, wherein the former and the lattice-type structure are fully or partially overwound with fibres in a resin matrix or overlaid with a coating material.

9. A method according to any one of claims 1 to 8, wherein the fibres comprise wires formed from steel, aluminium, copper or other high modulus metal.

10. A method according to any one claims 1 to 8, wherein the fibres are formed from carbon-fibre, glass fibre, Kevlar (Trade Mark) or other reinforced plastics.

11. A method according to claim 10, wherein the fibres are impregnated or coated with resin before the placement operation.

12. A method according to any one of claims 1 to 10, wherein the resin is injected into the channels of the former after emplacement of the fibres.

13. A method according to any one of claims 1 to 12, wherein the fibres are laid under control of a winding machine.

14. A method according to any one of claims 1 to

13, wherein the lattice-type structure defines a ladder, grid, beam or pylon, or support member, or a shell with an integral structural frame.

15. A method of producing a lattice-type structure substantially as herein described with reference to the accompanying drawings.

16. A lattice-type structure formed by a method as defined in any one of claims 1 to 15.

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